Measuring Honey Quality--- A Rational Approach[1]

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MY PURPOSE is to discuss two small but important aspects of international honey standards. I do not speak as a representative of the U. S. Department of Agriculture, since I no longer have any official connection with honey, and I have not cleared or even discussed my remarks with those in this country or elsewhere who have commercial interests in honey. My interest in the matter and my qualification to speak, if you will, arise from a 17-year period of full-time research on honey, during which I attempted to become familiar with the points of view of all parts of the world honey industry, past and present. I cannot say that I have succeeded in this. Perhaps this will be obvious when by proposing a middle course I will have earned the opposition of all and agreement with none.

I am sure that most are aware that an international effort is presently being made to establish trading standards for many different food materials, one of which is honey. It is in the general interest of the U. S. honey industry to cooperate as much as possible in the establishment of these standards; it is evident that some sort of standard will be approved by the major importing countries and, even should the U. S. not subscribe to the terms of the Codex, its trade with these countries would be carried out under the Codex standards.

Many of the proposed norms will present no problem to this country's exporters. One in particular did have most serious implications; I refer to the setting of limits for ash content between 0.08 and 0.40 percent. This was contained in the May 1966 draft standard. In the October 1966 draft the lower limit was eliminated, so we need not consider it further.

Let us next examine the question of HMF and enzyme assays of honey as related to quality. HMF, or hydroxymethylfurfural, is formed by reaction of certain sugars with acid. In times gone by honey was frequently adulterated with invert sugar, which was generally made by treating cane or beet sugar with acid. A convenient way to reveal this practice was by applying certain color tests, developed by Fiehe, Feder, and others. After difficulties were encountered with apparently positive tests being shown by non-adulterated honey, it was realized that the substance, HMF, which produced the color test can also be formed in honey by heating. Within the past few years honey chemists have learned to measure this material quantitatively in honey, and it is being more used now to indicate heating than adulteration of honey. I will consider this later.

The use of diastase measurement to assess the quality of honey extends over more than fifty years and will not be reviewed here. Several countries presently include minimal values for diastase in their honey standards. From the technical viewpoint, it is not clear to me why this is a requirement. Probably since table honey is required to have as little heat exposure as possible, and diastase is sensitive to heat, it was assumed that the extent of heat exposure could be estimated simply by measuring the diastase level, with it thus functioning only as an indicator material. Some propose that invertase (sucrase) levels be measured as well.

On the other hand, there appear to be some who believe that these enzymes in honey can serve a useful purpose in the human diet, that they are valuable in their own right. Let us consider the implications of both positions.

First, can enzyme activity indicate the degree of heat exposure of honey? This is implied by language in standards that read "overheated honey is honey which has been heated to such an extent as to inactivate partially or completely the enzymes it contains" (Codex, Oct. 1966).

There are two fallacies in this type of reasoning: (1) that only heat will cause loss of enzyme activity, and (2) that it is possible to measure partial inactivation of diastase in honey.

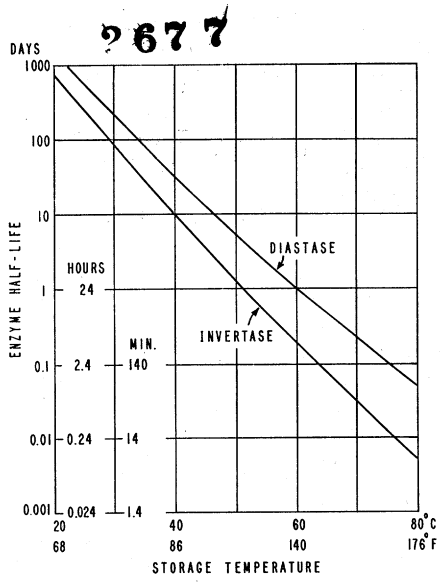

Fig. 1. Approximate time required at a given temperature between 20°C and 80°C for diastase and invertase activity in honey to be reduced to one-half the starting value.

In the first case, it is now quite generally recognized that long storage at moderate temperatures as well as overexposure to high temperatures will inactivate honey diastase. These are two aspects of the same phenomenon and their relation is easily seen in Figure 1.

In this Figure we see the length of time—on the vertical scale—required for the enzyme level to fall to half of its original value when honey is exposed to temperatures between 20°C (68°6) and 80°C (176°F) as shown on the horizontal scale. It can be seen that a single line passes through the half-life values at all temperatures studied. This means that destruction of diastase by so-called "overheating" and by long-time storage at moderate temperatures is caused by the same reaction. As an example, 200 days (6½ months) storage at 30°C (86°F) is exactly equivalent to 5.3 hours at 70°C (158°F) as far as diastase loss is concerned; under these conditions the diastase number will be reduced to half the starting value.

The second, and to my mind the more serious fallacy, is that a single diastase determination will provide an idea of heat and storage history of a honey. This requires that a starting diastase value is either known or assumed. This is not a tenable assumption since diastase content of fresh unheated honey is known to vary over a wide range and hence there is no correct starting point from which to calculate heat damage. The entire approach is in error because of this factor.

It is becoming somewhat apparent that importers (or at least, honey scientists) are recognizing that fresh natural unheated honeys of certain types

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can be low in enzyme content and should not be excluded or down-graded on this basis alone. To differentiate these enzyme-poor types from overheated honey the presence of low HMF values in the former may be required. Another approach to deal with this is that suggested last year by Duisberg and Hadorn in which the ratio of sucrase to diastase ("Kiermeier ratio") must exceed 0.5. This value decreases as honey is heated, due to the greater heat-sensitivity of the sucrase. This would seem to eliminate the need to assume any starting value for either enzyme, but does require that the ratio be relatively constant for fresh honey, and decline in a predictable manner. Whether this is actually the case remains to be proved. It is generally agreed that sucrase is more heat-sensitive than diastase.

In Figure 1 it may be seen that the invertase line is lower, which means a shorter half-life than diastase at any temperature. Note that these lines are not parallel, i.e. they diverge at the high-temperature end. This means that not only is invertase destroyed faster than diastase at any temperature, but the warmer the temperature, the greater the difference in rate of destruction becomes. For example at 23°C (72°F) the half-life of honey invertase is about half that of diastase. However, at 50°C (122°F) it is only one-fourth, and at 70°C (158°F) the half-life of invertase is only one-seventh that of diastase. These differences are not easily seen in the figure because it is on a logarithmic scale. For these reasons it seems that requiring a minimum value for invertase or for the Kiermeier ratio is not a practical approach to honey quality standards.

Now consider the alterate explanation of the reason for emphasis on diastase values which is sometimes heard —that honey diastase is a valuable material in the dietary and should therefore be maintained as high as possible. Let us consider a comparison with salivary amylase of the human. If we measure the diastase activity of normal human saliva and calculate in the same units as for honey diastase we find it to have a diastase number in the range of 3000-4500. Compare with the 40-50 for a very active honey. Furthermore, an average human output for saliva is 1200-1500 ml per day, so we secrete around 3,600,000-7,000,000 units of salivary amylase per day normally. And if this comparison is not convincing, we are also told that salivary amylase digestion of starch is not actually important; it soon ceases in the stomach, and that pancreatic amylase does most of the work; people can have

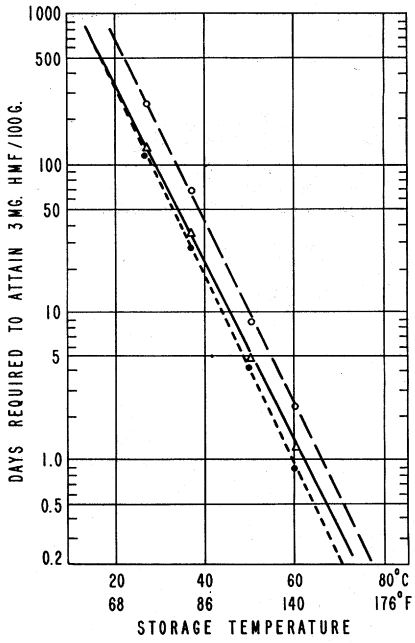

Fig. 2. Time required for three honey samples to accumulate 3 mg HMF per 100 g when stored at any temperature between 15 and 80°C. See text for identity of samples.

no salivary amylase and not even miss it.

If enzyme assays are not used as honey quality measures, what should be used to provide an indication for excessive storage - heat exposure? It should be a factor easily measured, not present in fresh honey so as to avoid the question of variable starting level, responsive in a predictable fashion to the environment, and independent of honey type or composition in this response. Needless to say, we know of nothing that fills all of these requirements. One material does answer all but the last item, and that, of course, is hydroxymethylfurfural, or HMF.

There is nothing new here; HMF has been known and measured in honey for many years. The chemistry of its formation in honey will not be discussed here.

It is remarkable that we know so little about a material known to form in honey and also used for so many years to indicate adulteration of honey. Relatively little accurate analytical work has been done with it in respect to honey. I propose that a thorough planned research study be made on an international basis of all of the factors in honey affecting the formation of HMF such as acidity, mineral content (especially iron), moisture content, HMF level, pH, and so on. Also, that a study be made of the effect of environment (time at various temperatures, from –20°C to 100°C) on the HMF content of a wide range of honeys. In addition, a study of analytical methods including exchange of samples of honey must be undertaken. Also, administrative determination should be made of the limits of acceptability in the trade for the various heat-sensitive factors that appear so important to European consumers.

All of this information could then be considered in establishing a formula in which suitable allowance is made for those honey compositional factors found pertinent to HMF accumulation rate. Such formula, using the HMF level found by analyses, would serve to indicate if a honey is acceptable in international trade for the various kinds of use.

A very small amount of information of the sort needed is presently available. Figure 2 shows the time needed for each of three honey samples to accumulate a given level of HMF at any temperature from 20°C to around 80°C. In this example the level is 3 mg HMF/100 g honey. Here again, just as with the loss of enzyme seen in the first Figure, a straight line is obtained, meaning that the same reaction is followed in production of HMF in honey by long-term storage at room temperatures as by short-time but higher-temperature treatment. We see that the three honeys differ somewhat in response. The upper line is for a clover honey, the lower two are both goldenrod (*Solidago* spp.)-aster. The possible causes of this difference cannot be examined here. The fact that there is a difference is important.

The present draft of the Codex standard specifies a maximum of 3 mg HMF per 100 grams of honey. By reference to Figure 2 we can see that this amount of HMF can be reached by 100 days storage of honey at 77°F (25°C) which is not an excessively warm condition; in fact, less than a year (300 days) at 68°F (20°C) will do it for some kinds of honey; for another type about two years of such storage is required. At first glance the three honey samples shown on this chart may not seem to differ greatly in their rate of accumulation of HMF. This is due to the type of plotting used in an effort to get all of the information on one chart. Actually the honey represented by the upper line must be stored twice as long as the ones shown by the lower lines at any temperature to produce the same HMF levels.

It is apparent to me that the U. S. honey industry does not seem to favor use of any indicator assays such as enzymes or HMF; while importing European countries in general seem to have an increasing degree of such requirements. I wish to propose a middle way—agreement on a single measure for determining this quality aspect of honey, but only after mutually supported and planned investigations of all of the pertinent factors. ●